MODEL 202A

A-C VOLTMETER

DESCRIPTION

OPERATION

MAINTENANCE

PARTS LIST

Shasta *division*

BECKMAN INSTRUMENTS INC.
P. O. BOX 296, STATION A,
RICHMOND, CALIFORNIA

WARNING

Voltages dangerous to human life may be encountered in the use of this instrument. The following list of precautions should always be observed:

1. Don't work with high voltages when you are tired or when others are apt to interrupt you.

2. Don't measure any voltage without knowing its probable magnitude. Never assume that an unknown voltage is low. Always double-check your setup before measuring high voltages. Don't operate the instrument in such a way that a significant potential exists between the common connection (metal case) and ground or power. Don't ground yourself to a waterpipe. Stand on an insulated pad if possible.

3. Don't work alone; help should always be available in case of injury. The Red Cross treatment for electrical shock should be posted in the working area.

4. The cautious and experienced worker will attempt to keep one hand in his pocket when he is holding a high voltage probe in the other; he will observe the safety precautions recommended by the manufacturer of the equipment under test.

DESCRIPTION

The Model 202A AC Voltmeter is designed to accurately measure a-c voltages from .0001 to 300 volts at frequencies of 20 cps to 3 megacycles. For ease of reading, the Model 202A incorporates a full-vision meter using a black knife-edge pointer against a white background.

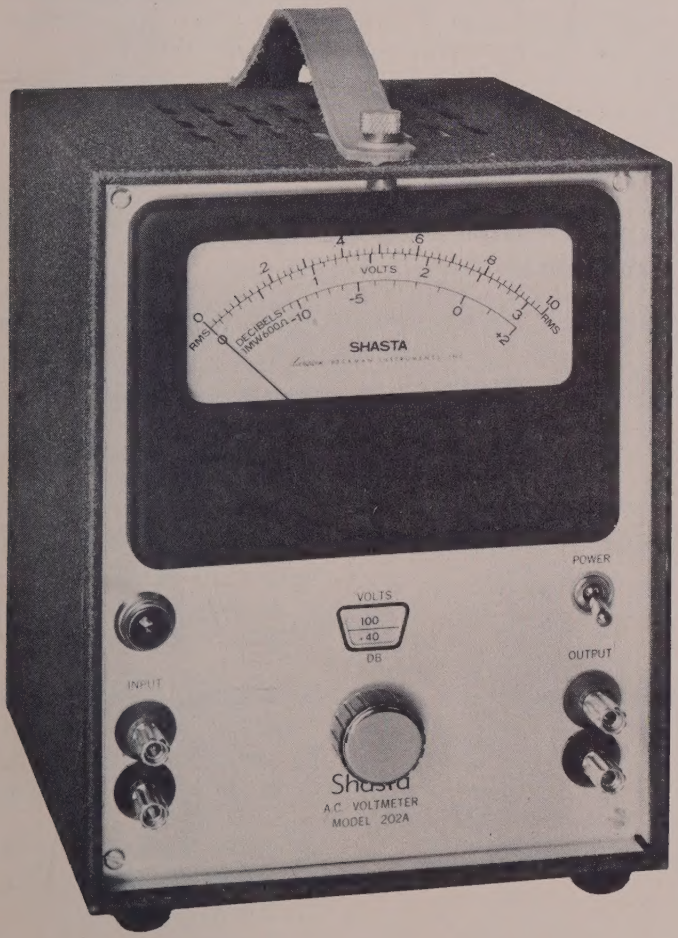


FIGURE 1 MODEL 202A AC VOLTMETER

Speed, accuracy and range of measurement are combined to offer a flexible and useful instrument covering the range of .001 to 300 volts, rms. Sensitive measurements of hum level, balance, detection, etc., as well as the more routine measurements of audio and rf voltages are now possible. Bringing separate terminals out for the input and output sections of the amplifier permits alternate use of the Model 202A as a high gain wide band amplifier. The amplifier has a maximum gain of 50 db for input voltages of .001 volts or less and lesser gains for higher voltages. With an input impedance of 10 megohms and 18$\mu\mu$f, errors caused by loading the circuit under test are minimized.

SPECIFICATIONS

Meter Ranges Volts Full Scale (calibrated rms values of sine-wave)	.001 to 100 by factors of 10 .003 to 300 by factors of 10
DB Ranges	-60 to +50 in steps of 10 db
Frequency Range	20 cps to 3 MC
Accuracy	±3% full scale to 2 MC ±5% full scale to 3 MC
Amplifier	Output Impedance - 1000 ohms Gain - 50 db on .001 v. range to 0 db on .3 v. range Output - .5 Volt maximum
Input Impedance	10 megohms shunted by 18 $\mu\mu$f on 1 to 300 V. ranges 10 megohms shunted by 25 $\mu\mu$f on .001 to .3 V. ranges
Tube Complement	1- 6SQ7 4- 6AK5 1- 6AV5GT 1- 6AV6 1- OA2 1- 6AX5GT 1 - 10-4C
Dimensions	7-5/32" wide x 8-11/16" deep x 9-5/32" high
Weight	13 pounds

SPECIFICATIONS - Continued

Power Requirements	117 volts ac ±10%, 50-60 cps at 60 watts
Maximum Safe Input	600 volts, the sum of the dc and ac peak voltage
Meter Movement	1 ma full-scale deflection

OPERATION

The Model 202A requires no special installation.

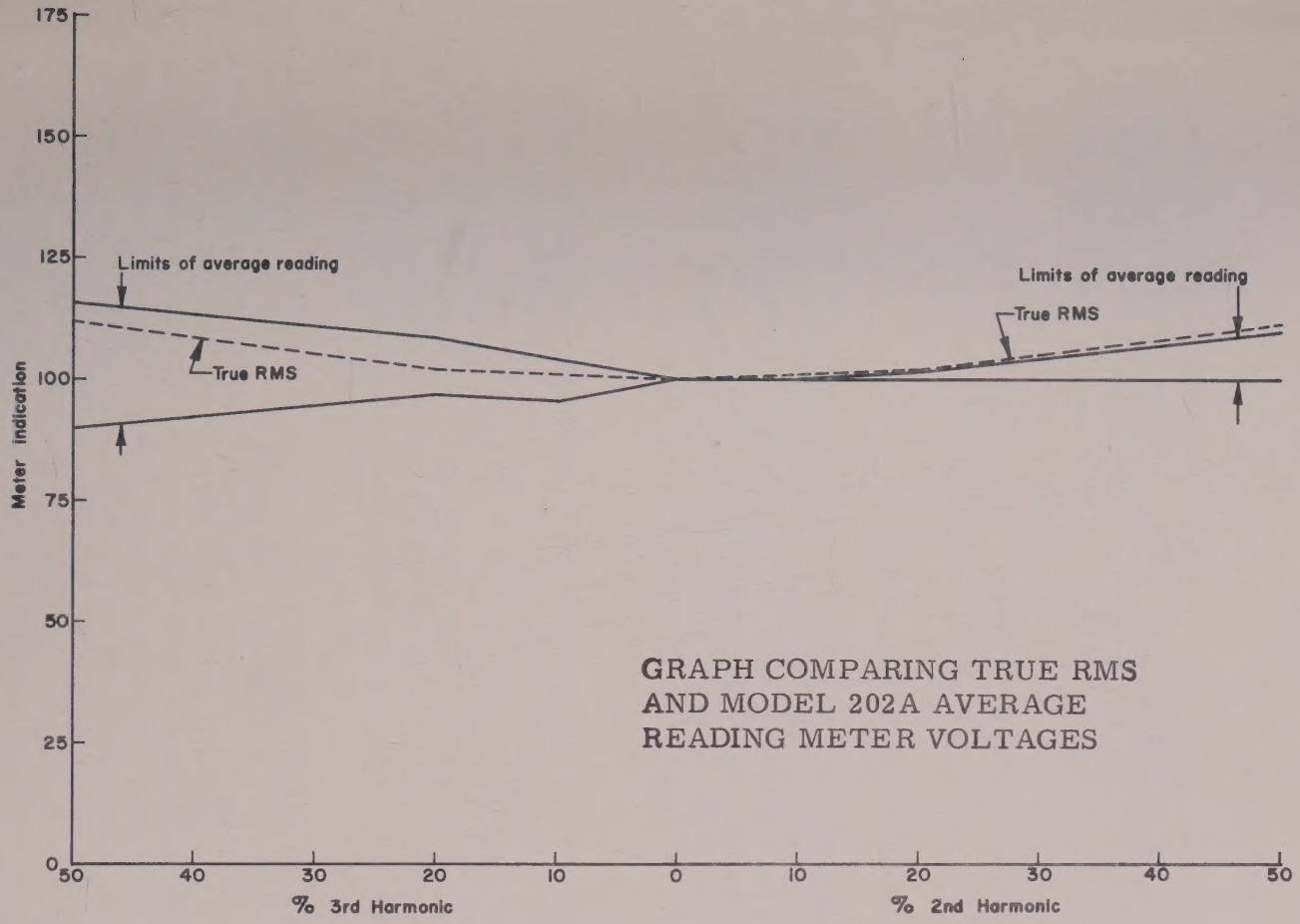
To operate the Model 202A, connect the power cord to any 117 volt ±10% 50-60 cycle source and turn the toggle switch ON. The front panel lamp will light when power is supplied. Permit the instrument to warm up for a minute or so before connecting an input. Although the meter may deviate as much as two scale divisions from zero on the lower scales after it has reached operating temperature, do not attempt to zero the pointer. The accuracy is in no way affected. Adjustments of this sort should be made only with the aid of proper test equipment during calibration (see Maintenance).

MEASURING AC VOLTAGES

To measure voltages, set the VOLTS-DECIBELS control on a range somewhat higher than the anticipated voltage. Connect the input terminals to the voltage under measurement and readjust the VOLTS-DECIBELS control for the desired range. Voltage readings should be made from the upper scale: .001, .01, .1, 1, 10, 100, from the top set of scale divisions; .003 .03, .3, 3, 30, 300, the bottom.

ACCURACY OF MEASUREMENT

The Model 202A is an accurate, precision built voltmeter. To obtain satisfactory results, the user is cautioned that all readings are average values of the a-c voltage under measure, even though the scale is calibrated in RMS values. As the harmonic content is increased, the accuracy of the reading normally decreases. However, in no case is the margin of error as great as that of a peak reading meter. The following chart compares true RMS values with those obtained from the Model 202A average reading meter.



GRAPH COMPARING TRUE RMS AND MODEL 202A AVERAGE READING METER VOLTAGES

AMPLIFIER

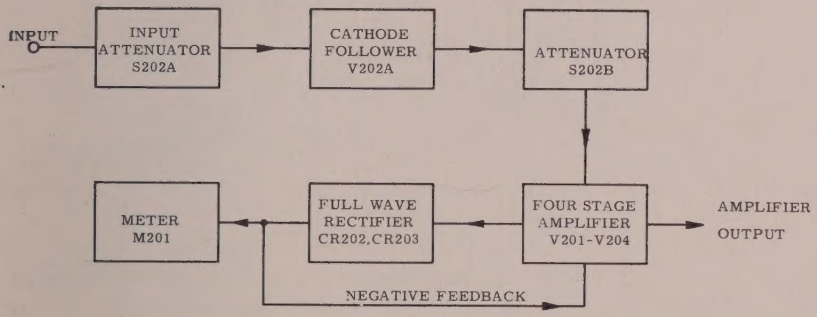
Used as an amplifier, a gain of 300 times the input voltage can be obtained on the .001 scale across an output load of 10K or more. The maximum input voltage that any range will amplify without excessive distortion is the amount causing full scale deflection. As the range control is advanced, the gain of the amplifier falls 10 db between stages, yielding a unity gain in the ".3" position and lesser gains at higher positions.

DECIBEL MEASUREMENT

Voltage measurements referenced in decibels may be made as described above if 600 ohms is placed across the input terminals. The algebraic sum of the range control setting, and the meter reading equals the correct decibel reading. For instance, with the range control in +40 and a meter deflection of -5, a reading of +35 decibels is indicated.

CIRCUIT DESCRIPTION

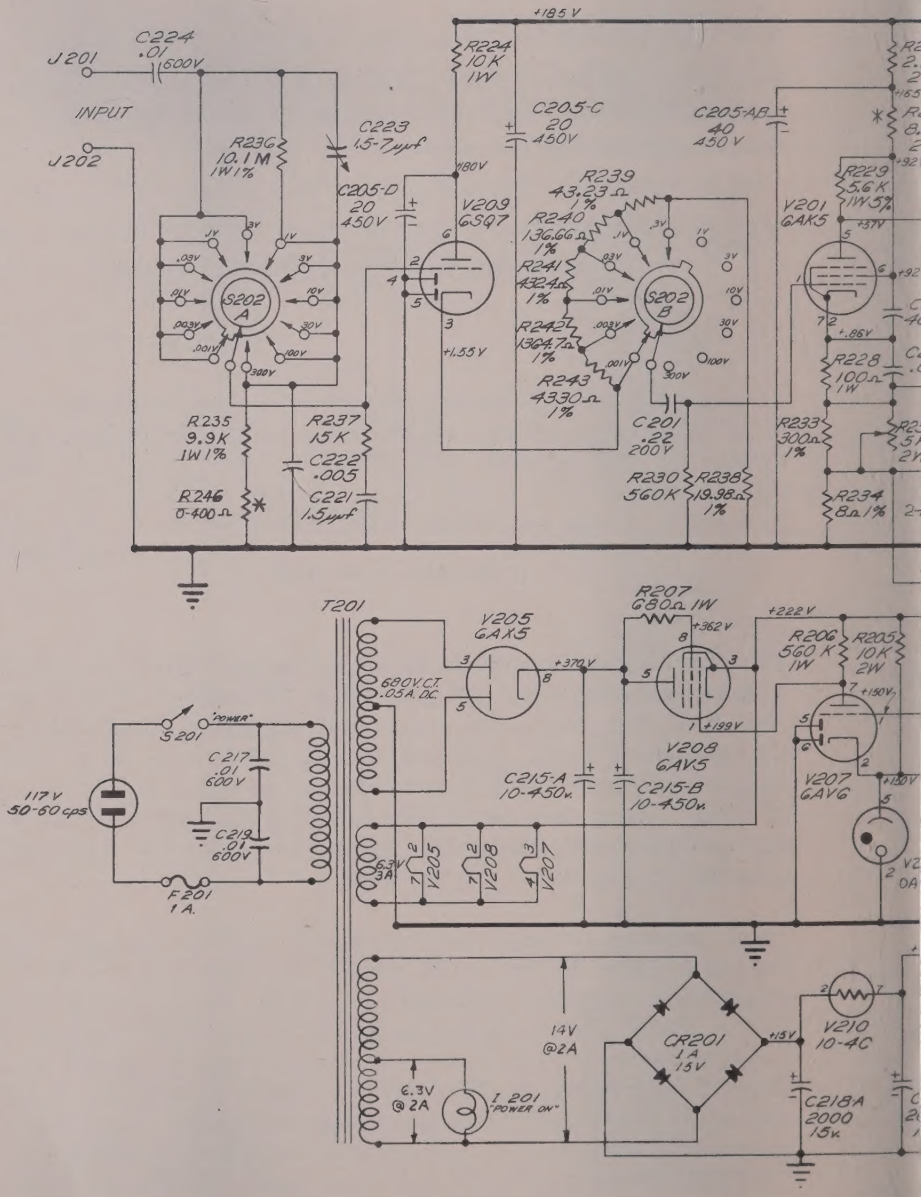
Basically, the Model 202A consists of : a two step input attenuator, cathode follower, six step attenuator, four stage amplifier, full wave rectifier and a meter.

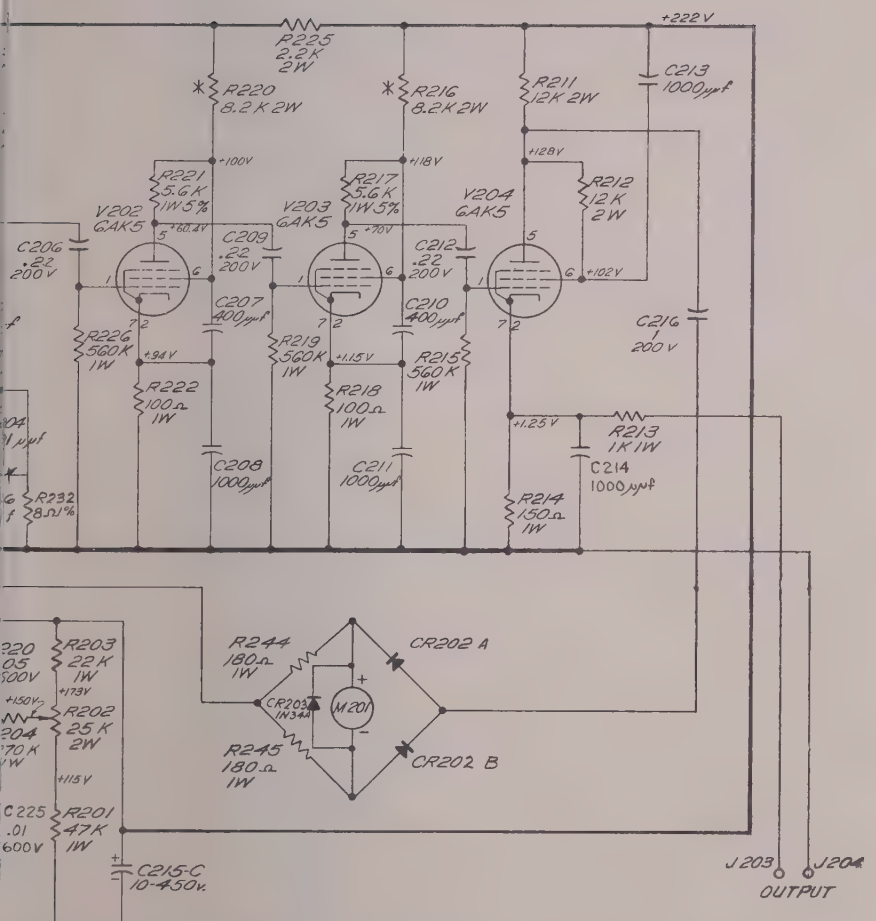


FUNCTIONAL DIAGRAM

The input signal is coupled through a dc blocking capacitor (C224) to the input attenuator (S202). With the range control set from .001 to 0.3 v. full scale, the input signal is coupled directly to the cathode follower grid (V209). In the 1.0 to 300 v. full scale range, the input attenuator reduces the input signal by a factor of 1000. From the cathode follower the signal is fed into six series resistors arranged to further attenuate the input signal by a factor of 0 to 300 in 10 db steps.

After passing through the attenuator-cathode follower network, the input signal is fed to the grid of the first tube of a four stage, resistance coupled, feedback stabilized, wide band amplifier (V201-V204). Overall negative feedback is used to achieve uniform response over a wide frequency range and to insure accuracy despite tube aging, replacement, or other parameter variations. The plate circuit of the output stage drives the metering circuit and feedback loop. The cathode circuit is brought out to the OUTPUT terminals on the front panel so that the instrument may also be used as a general purpose high gain amplifier. The amplifier output is coupled to a full wave rectifier employing a


J201
INPUT
J202
C224 .01 600V
R23G 10.1M 1W 1%
C223 1.5-7 μμf
C205-D 20 450V
R224 10K 1W
C205-C 20 450V
C205-AB 40 450V
+185 V
+180V
V209 6SQ7
R239 43.23Ω 1%
R240 136.66Ω 1%
R241 432.6Ω 1%
R242 1364.7Ω 1%
R243 4330Ω 1%
S202 A
S202 B
+1.55V
V201 6AK5
+137V
R229 5.6K 1W 5%
+92V
+86V
R228 100Ω 1W
R233 300Ω 1%
R234 8Ω 1%
C201 .22 200V
R230 560K
R238 19.98Ω 1%
R235 9.9K 1W 1%
R237 15K
C222 .005
C221 1.5 μμf
R246 0-400Ω
T201
V205 6AX5
680V.C.T. .05A DC.
+370V
R207 680Ω 1W
+362V
+222V
R206 560K 1W
R205 10K 2W
+150V
+139V
V208 6AV5
V207 6AV6
C215-A 10-450v.
C215-B 10-450v.
6.3V 3A
V205
V208
V207
S201 "POWER"
117V 50-60 cps
C217 .01 600V
C219 .01 600V
F201 1A.
14V @2A
6.3V @2A
I 201 "POWER ON"
CR201 1A 15V
+13V
V210 10-4C
C218A 2000 15v.



NOTE:
RESISTORS:
WATTAGE — ½W UNLESS OTHERWISE NOTED.
TOLERANCE — 10% " " "

CAPACITORS:
CAPACITY — IN μf UNLESS OTHERWISE NOTED.
VOLTAGE RATING — 500v " "

* — INDICATES AVERAGE VALUES — AFTER ADJUSTMENT AT FACTORY PART MAY BE OMITTED.

R 232 THRU R 234 INCLUSIVE & R 238 THRU R 243 INCLUSIVE 1% DEPOSITED CARBON.

ALL VOLTAGES MEASURED TO CHASSIS WITH METER HAVING A SENSITIVITY OF 20 KΩ/V. DC, 5 KΩ/V. AC.

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FIGURE 2 SCHEMATIC DIAGRAM, MODEL 202A

pair of germanium diodes with the indicating meter as the rectifier load. The rectifier output is also connected to a resistance capacitance voltage divider which is coupled to the cathode of the first amplifier stage, thus completing the negative feedback loop. The divider network is adjusted by R231 which varies the overall amplifier gain and is consequently used to calibrate the instrument.

Since the amplifier is used in the measurement of very low level signals, the hum level must be kept as low as possible. This is accomplished primarily by a DC supply for the cathode follower and amplifier filament supplies. The supply consists of a full wave bridge type selenium rectifier followed by a non-linear resistance capacitive filter which also maintains a constant filament voltage variation over a wide line voltage.

The high voltage supply consists of a conventional high vacuum full wave rectifier coupled to a series type electronic voltage regulator. Varying R202 alters the bias on V207 thereby regulating the output voltage. Additional resistance capacitance filtering is used between the high voltage supply and the low level amplifier stages. The use of voltage regulation in the high voltage supply further isolates the instrument from line voltage variations affecting the voltmeter accuracy.

CALIBRATION

Proper calibration of this instrument requires exact and precise procedures. Therefore, we recommend return of the instrument to the factory for such service. The following instructions are included as a guide where this is not feasible.

Instruments required:

Voltmeter (20, 000Ω/v or VTVM)

Audio Oscillator (Shasta Model 301 or equivalent)

Thermal Voltmeter (Sensitive Research Model A or equivalent)

High-frequency voltmeter (Model 202A or equivalent)

Proceed as follows:

1. Remove the chassis from the case by unscrewing the knurled thumb screws which hold the leather strap on and withdraw the chassis assembly.

2. Before calibrating the Model 202A, adjust R204 for 220 volts, regulated B+.

3. Short out the meter and adjust the mechanical zero by varying the screw on the lower center of the meter frame.

4. Connect a 560 ohm and a 68 ohm resistor in series across the audio oscillator output terminals with the 68 ohm resistor nearest the ground. Connect the output from the oscillator between the junction of the 68 ohm and the 560 ohm resistor and ground to the input of the Model 202.

5. Set the oscillator at 100 cps. Connect the thermal voltmeter across the 68 ohm resistor. Adjust the oscillator output for 1.0 rms volts according to the thermal voltmeter. Set the range control on the Model 202A on the 1.0 volt rms scale and remove the meter short.

6. Adjust R231 until the voltage reading on the Model 202A agrees with that of the thermal voltmeter. Unless attenuator resistors are out of tolerance, the low frequency calibration is completed (see step 6).

7. Adjust the input voltage from the oscillator to .3 rms volts at 100 cps. Shift the range control to the 0.3 volt scale. If the voltages do not agree, the value of R246 must be changed. If the reading on the 0.3 volt scale is high, increase R246 if too low, decrease R246.

8. When agreement between ranges is obtained, repeat steps 5 and 6 and apply staking lacquer to the shaft of R231.

9. Set the oscillator outfit for 2 MC at .001 V as measured by the reference H.F. Voltmeter. Adjust C226 with an alignment tool for correct reading.

10. Set the oscillator for 700Kc. and 0.3 rms volts according to the .3 volt scale on the Model 202A. Switch to 1.0 volt scale and adjust C223 with an alignment tool for correct reading. This completes calibration.

11. As a check on linearity set the oscillator at 100 cps. Check the Model 202A scale for agreement with the thermal voltmeter at the following points on the one volt scale: 0.3 volts, 0.4 volts, 0.6 volts, 0.8 volts, 1.0 volts. If necessary, readjust mechanical zero for best tracking and repeat steps 5 to 10.

TROUBLESHOOTING

The Model 202A is carefully built to give long, trouble-free service. However, subject to abusive use or after many hours of satisfactory operation, certain circuit elements may require replacement. Tubes are, of course, the most frequent source of malfunction in any electronic instrument. If trouble occurs, check tubes before going further.

It may be necessary to select V201 or V209 for low noise characteristics and absence of microphonics. V201 should have a G_m of 4500 ±10%. Measure the filament voltage between pin #7 of V210 and ground whenever a 6SQ7 or 6AK5 type is replaced. The voltage should be not more than 6.7 nor less than 6.0 volts. To lower the filament voltage, decrease the value of R208; to raise the filament voltage, increase the value of R208. In either case, permit the instrument to operate for at least 30 seconds before determining whether the new value of R208 is satisfactory.

When troubleshooting or replacing components on the amplifier sub chassis, removal of the meter will completely expose the amplifier circuitry. All servicing may then be accomplished through the meter hole in the front panel.

CHART OF COMMON TROUBLES

Symptom	Cause	Remedy
Instrument inoperable, pilot light out	Blown fuse	Clear short and replace fuse.
Instrument inoperable, pilot light lit	Tube failure	Check V209 and V201-V204.
	No high voltage	Check V205 high voltage rectifier, V208 series regulator, all filter capacitors.
	No amplifier filament voltage	Check for glow in V210; if none, replace.
Meter oscillates at a low frequency	Common coupling	Isolate output and input leads to a greater degree.
	Improper regulator operation, B+ voltage incorrect, no adjustment	Check V207 regulator amplifier, V206.
	Feedback incorrect	Check for shorted R231.
Meter indication grossly incorrect.	Common coupling	Further isolate output from input.
	Open or shorted attenuator	Check attenuator switch S202. Check R235, R246 R236, R238 through R243.
	Feedback incorrect	Check for open R231; if meter oscillates, check for shorted R231.

CHART OF COMMON TROUBLES

Symptom	Cause	Remedy
Scales above 0. 3V are incorrect (Meter forced on pin for inputs less than 1V)	1, 000:1 attenuator open	Check R235 and R246 and its connection to front wafer of S202 (S202A).
Scales above 0. 3V give no indication	1, 000:1 attenuator shorted	Check R236 and its connection to S202A.
Scales are incompatible	Attenuator resistors incorrect due to aging, instrument out of calibration	If low frequency disagreement occurs between 0. 3V and 1V scale, check 1, 000:1 attenuator R235, R246 and R236. If disagreement is found within the band 1V to 300V (i. e., if meter reads 1V on 1V scale and does not read 1V when switched to 3V scale) then this same disagreement will be found in the ranges 0. 001V to 0. 3V. Check R238 through R243. If there is only high frequency disagreement between 0. 3V and 1V ranges, instrument must be recalibrated by adjusting the capacitive compensator C223 (see Calibration)

LIST OF CRITICAL COMPONENTS

Should replacement be necessary, the components listed should be duplicated exactly. These may be obtained from the factory if not locally available. Parts not listed but shown on the schematic are standard and may be replaced by the same values.

Detail No.	Stock No.	Description
		RESISTORS
R202	1-2169	Potentiometer, 25K, 2W, 20% linear
R209	S1-3480	5Ω, 2W, 10% WW
R232, 234	S1-3483	8Ω, 1/2W, 1% carbon film
R233	S1-3484	300Ω, 1/2W, 1% C.F.
R235	S1-6249	9.9K, 1W, 1% C.F.
R236	S1-6250	10.1M, 1W, 1% C.F.
R238	S1-3488	19.98Ω, 1/2W, 1% C.F.
R239	S1-3489	43.23Ω, 1/2W, 1% C.F.
R240	S1-3490	136.66Ω, 1/2W, 1% C.F.
R241	S1-3491	432.4Ω, 1/2W, 1% C.F.
R242	S1-3492	1364.7Ω, 1/2W, 1% C.F.
R243	S1-3493	4330Ω, 1/2W, 1% C.F.
		CAPACITORS
C201, 206 209, 212	S2-6076	.22 μf, 200V, paper
C202, 207, 210	2-2172	400μμf, 500V, 10% Mica
C203, 208, 211 213, 214	2-3065	1000μμf, 500V, 10%, Mica
C204	S2-5576	91μμf, 500V, 10%, Mica
C205	S2-5746	4 x 20μfd, 450V, electrolytic
C215	S2-5748	3 x 10μf, 450V, electrolytic
C216	S2-5750	1.0μf, 200V, metalized paper
C217, 219, 255	2-2230	.01μf, 600V, Ceramic Disc
C218	S2-5749	2 x 2000μf, 15V, electrolytic
C221	S2-3475	1.5μμf, 500V, ±10%, Mica
C222	2-1987A	5000μμf, 500V, ±5%, Mica
C223	2-3355	1.5-7μμf, Ceramic Trimmer
C226	2-2326	2-25μμf, Var. Trimmer

Detail No.	Stock No.	Description
		MISCELLANEOUS
XV201, 202 203, 204	S4-5751	Socket, 7 pin, turret w/shield base
XV205, 208 209, 210	4-2377	Octal
XV206, 207	4-0464	7 pin, min. w/shield
T201	S6-5752	Transformer, 117V, 650Vct, 6.3-13.5V
CR201	S8-5753	Selenium Rectifier, Fullwave 1A, 15V
CR202	S8-5754	IN35 (matched to CR203)
CR203		Same as CR202
S201	12-1643	Switch, SPST
S202	S12-5765	Switch, 12 position, 3 section, w/shield
M201	S15-5756	Meter, 0-1ma
J201, 202 203, 204	S17-5703	Binding Post
	S17-5704	Binding Post Insulator red
	S17-5705	Binding Post Insulator black
	S24-5669	Knob, 1" round
I201	S21-1677	Lamp, Type # 47
F201	S7-0789	Fuse, 1Amp, 250V, 3AG

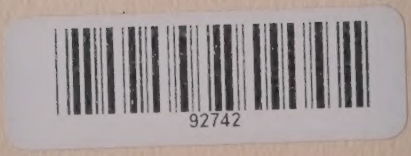
WARRANTY

Every instrument manufactured by the Shasta division of Beckman Instruments, Inc. is warranted to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes, which shall within one year from date of shipment to the original purchaser prove to be defective after our examination.

Instruments to be repaired must be returned to the factory with transportation charges prepaid. Repair work will be performed only upon receipt of a written purchase order or authorization.

Claims for damage in shipment should be filed promptly with the transportation company. All correspondence concerning the instrument should specify the model and serial number. This information appears on the instrument.

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing.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